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Science Based Stockpile Stewardship, Uncertainty Quantification, and Surrogate Reactions

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Stewardship of this nation's nuclear weapons is predicated on developing a fundamental scientific understanding of the physics and chemistry required to describe weapon performance without the need to resort to underground nuclear testing and to predict expected future performance as a result of intended or unintended modifications. In order to construct more reliable models, underground nuclear test data is being reanalyzed in novel ways. To improve the interpretation of these experiments with quantified uncertainties, improved nuclear data is required.

As an example, the thermonuclear yield of a device was often inferred through the use of radiochemical detectors. Conversion of the detector activations observed to thermonuclear yield was accomplished through explosion code calculations (models) and a good set of nuclear reaction cross-sections. Because of the unique high-fluence environment of an exploding nuclear weapon, many reactions occurred on radioactive nuclides, for which only theoretically calculated cross-sections are available. Surrogate nuclear reactions at STARS/LIBERACE offer the opportunity to measure cross-sections on unstable nuclei and thus improve the quality of the nuclear reaction cross-section sets.

One radiochemical detector that was loaded in devices was mono-isotopic yttrium (^{89}Y). Nuclear reactions produced ^{87}Y and ^{88}Y which could be quantified post-shot as a ratio of ^{87}Y/^{88}Y. The yttrium cross-section set from 1988 is shown in Figure 1(a) and contains approximately 62 cross-sections interconnecting the yttrium nuclides. The 6 experimentally measured cross-sections are shown in Figure 1(b). Any measurement of cross-sections on ^{87}Y or ^{88}Y would improve the quality of the cross-section set. A recent re-evaluation of the yttrium cross-section set was performed with many more calculated reaction cross-sections included [1].

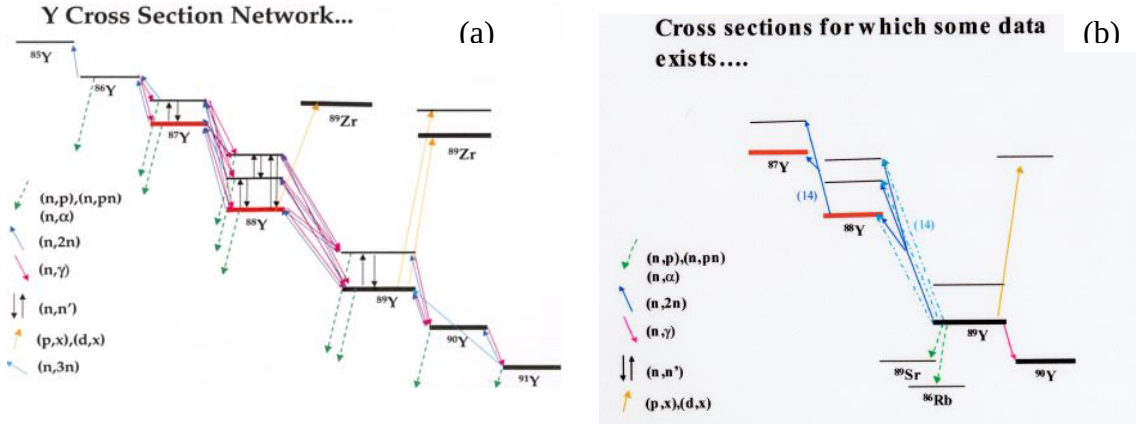

Fig. 1: The radiochemical cross-section set used for yttrium (a) and those cross-sections where experimental data exists (b). Reactions affecting the production or destruction of ^{87}Y and ^{88}Y are of interest to the Science Based Stockpile Stewardship program. Note several cross-sections are only measured at 14 MeV and only one cross-section on a radioactive target (^{88}Y(n,2n)^{87}Y) has been measured.

[1] R.D. Hoffman, et al., UCRL-TR-222275 (2006).